Specific Heat of Aluminum

Introduction

The specific heat of a substance is the amount of heat required to raise the temperature of the substance by a specified amount. The specific heat is usually quoted in terms of calories/degree.gram, but the Joule/degree•kilogram is also used.

When two objects at different temperatures are brought into thermal contact heat flows from the hotter object to the colder object until the temperatures of the two objects are equal. In this lab we use that fact to determine the specific heat of aluminum.

When an amount of heat ΔQ_{in} flows into an object its temperature changes by an amount given by

$$\Delta Q_{in} = M\,C\,(T_f - T_i) \qquad (1)$$

In Equation (1) M is the mass of the object, C the specific heat, T_f is the final temperature and T_i is the initial temperature. If two thermally isolated objects are brought into contact then the heat flowing out of one object flows into the other, so that

$$M_A\,C_A\,(T_{fA} - T_{iA}) = -M_B\,C_B\,(T_{fB} - T_{iB}) \qquad (2)$$

In Equation (2) the subscripts A and B refer to the two different objects. The minus sign on the right-hand side of Equation (2) indicates that heat flows *out* from object B. If the objects come into thermal equilibrium, then

$$T_{fA} = T_{fB} \qquad (3)$$

Procedure

In this lab you take a sample of aluminum at room temperature and immerse it in a cup of hot water in order to determine the specific heat of the aluminum. Heat flows from the water to the aluminum, raising the metal's temperature and lowering the temperature of the water.

You should begin by taking three 12 ounce Styrofoam cups that are nested together and filling them with about 200 milliliters of hot water provided by the lab instructor. Attach two clothespins to the temperature probe so that you can suspend the metal part of the probe in the hot water and not get the plastic part wet. Record the temperature at 30 second intervals for 7 minutes. The initial temperature should be in the range 190^oF to 200^oF. Plot the temperature on the vertical axis of a graph, and the time on the horizontal axis. This is your calibration curve for the Styrofoam calorimeter.

Weigh your piece of aluminum. Weigh three empty dry Styrofoam cups.

For the second run you take three more Styrofoam cups and acquire about 200 milliliters of hot water from the lab instructor. When the temperature is approximately 195^oF, carefully drop in the piece of aluminum. Measure the temperature at 30 second intervals for 7 minutes.

You will notice that the temperature drops, and then remains constant for some time before declining again. The temperature of the water will not decline until the aluminum and the water come to thermal equilibrium. During this time heat is also escaping from the calorimeter. The earlier data that you took as a calibration curve enables you to compensate for the heat lost from the calorimeter while the aluminum and the water are coming to thermal equilibrium. Consult Figure 1 to see where on the temperature versus time graph you should take the temperature difference.

Weigh the hot water plus the aluminum in order to determine the mass of the water in the cups. Assume that the specific heat of water is one calorie per gram per Kelvin. The molecular weight of aluminum is 27. Calculate the specific heat of aluminum from your data, and calculate the percentage difference from the expected molar specific heat of $3R$, where R is the ideal gas constant.

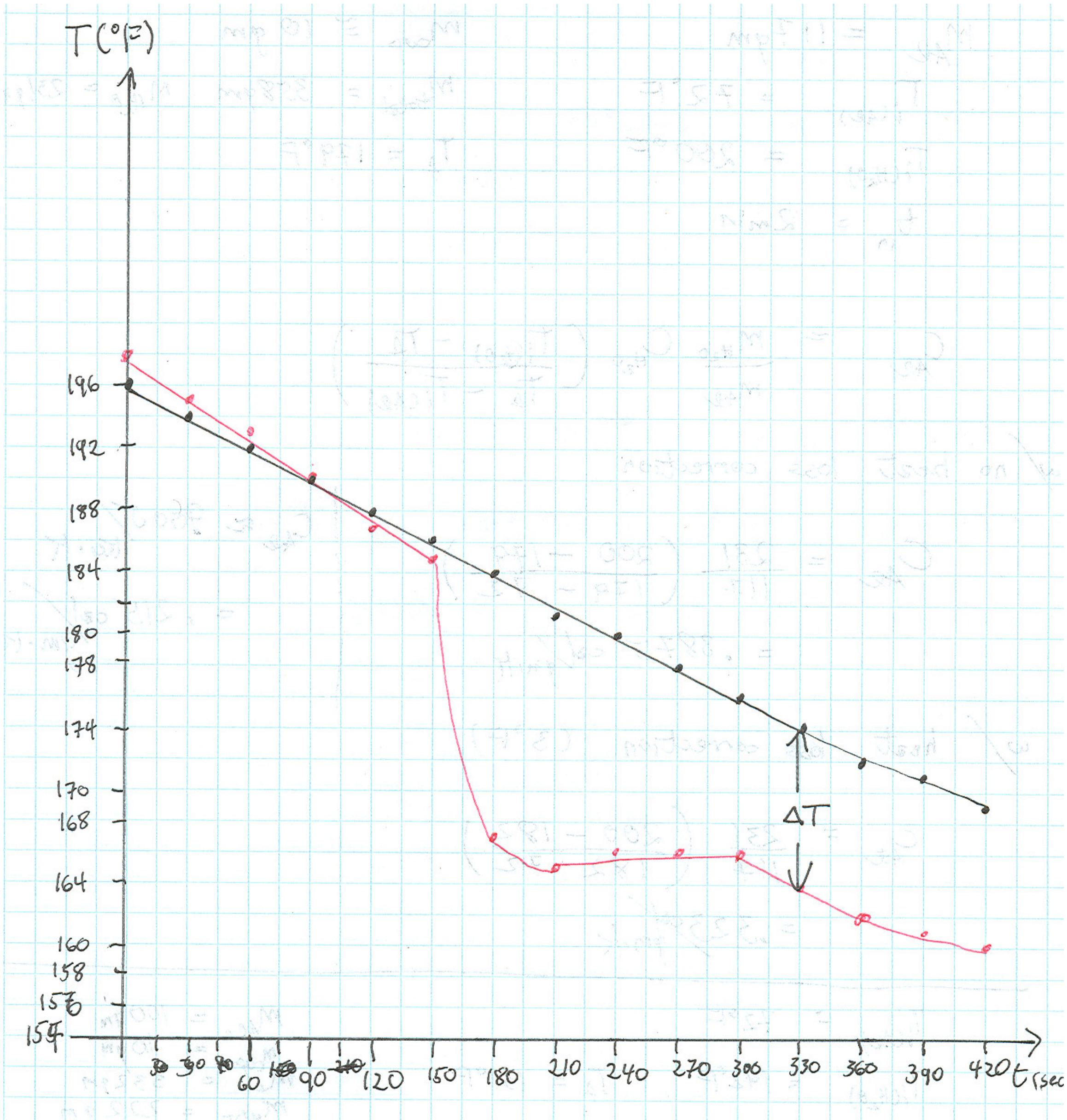

Figure 1